

Evolution



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* Introduction

- Evolutionary Biology is the study of past of life forms present on Earth.
- Changes in flora and fauna that have occurred over millions of years, is known as evolution.
- Evolution is a slow and continuous process.
- Evolution means to unfold or unroll.
- We will study:
 - origin of universe
 - origin of Earth
 - origin of life

Case:- When we're looking at a star, actually we are peeping into the past.

Reason:- Stars are trillions of kilometers far from us. Light reflected from stars takes millions of years to reach our eyes. Hence, what we are looking today, is actually the position of a star millions of years ago.

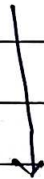
- Stellar distances are measured in light years.

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* Origin of Universe

- Origin of universe = 20 BYA
- Origin of universe explained by BT or BAN theory (by Abbe Lemaitre)
- Big bang theory ÷ single huge massive explosion
→ unimaginable in physical terms

Single entity



explosion

many nebulas form
tem. cool down

Hydrogen, Helium formed later



stars, clouds of gases and dust condensed
under gravity and form galaxies



Many galaxies formed, one of them is our
galaxy (milky way or Akash ganga)



In our galaxy, there is solar system which
includes our planet, Earth

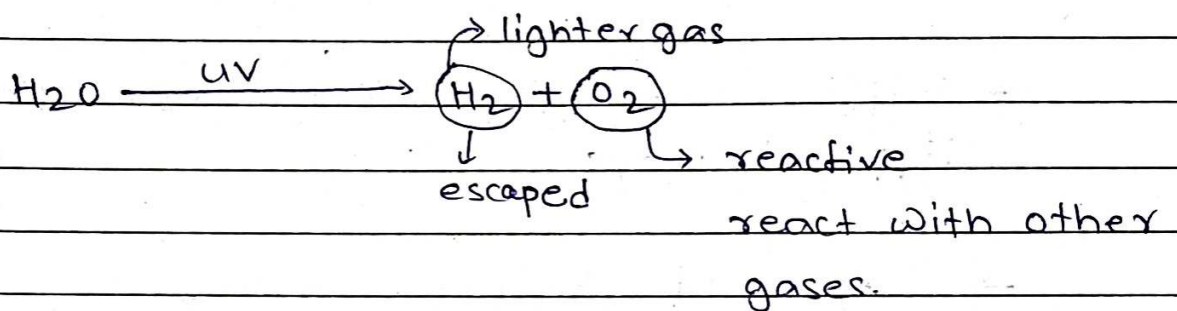
→ Formed 4.5 BYA



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- Early earth has no atmosphere
- Volcanic eruptions occur which releases H_2O vapour, CO_2 , NH_3 , CH_4
- No ozone was there, UV light easily present on earth.



- When atmosphere formed it was reducing type
↓
no free O_2 found
- Also, there was rain for many years, which filled the depression on earth and formed Oceans.
- Life originated in water about 500 million year after formation of earth (i.e. 4ByA)



* Origin of life.

Many theories are given to explain the origin of life on earth.

(1) Theory of special creation.

→ A/c to this theory, life was created by God.

→ Different religion literature explain it in different ways.

→ Support of Father Saurer.

→ A/c to this theory, age of Earth is 400 years.

→ Diversity in ~~am~~ animals is same as early earth and will be same in future.

→ No scientific proof, this theory was discarded.

(2) Theory of panspermia

• Also known as theory of extra-terrestrial life or cosmozoic theory.

• A/c to this theory, life came from different planet on Earth in the form of Spores
(unit of life)

• Early greek thinker believed this theory.



Given by **Arrhenius**

many ~~may~~ astronomers still believe this theory.

(3) **Theory of Abiogenesis**

Also known as theory of **spontaneous generation**

Abiogenesis $\longrightarrow$ life from non-living thing
not life $\searrow$ $\swarrow$ $\rightarrow$ formation

A/c to this theory, life arise spontaneously from non-living matter like $\div$ straw, mud etc

e.g. mice spontaneously formed in the dark room filled with straw.

This theory disproved by experiment done by Louis Pasteur.

(4) **Theory of Biogenesis**

A/c to this theory, life came from pre-existing life.

Biogenesis

life formation



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- Demerit: This theory doesn't explain how 1st life originated on Earth.
- Louis Pasteur, Redi, Spallanzani are 3 scientists who work on providing life comes from pre-existing life.
- Louis Pasteur performed Swan Neck experiment.
 - ↳ Disproved theory of Abiogenesis
 - ↳ proved theory of Biogenesis
- Swan-neck experiment

Case 1: pre-sterilized swan-neck shape flask



prepare broth (nutritive-medium)

H₂O + sugar + killed yeast



Boil it



No growth of bacteria from killed yeast or rotting material

Conclusion: Theory of Abiogenesis disproved

note: Air from outside get trapped in - the swan neck of flask.



Case II Same as case I, but break Swan-nick of flask



Air can easily enter in the flask. Air have micro-organism which successfully grow in broth



growth of micro-organism seen.

Conclusion: life came from pre-existing life (New micro-organism from pre-existing micro organism)

Theory of Biogenesis is proved

(B) Theory of chemical evolution or Chemogeny

• Given by Oparin (Russia) and Haldane (England)

• Also known as Oparin-Haldane's theory

• A/c to this theory, 1st life was created from non-living organic molecule.

• free atom $\rightarrow$ inorganic molecule $\rightarrow$ Simple organic molecule $\rightarrow$ complex organic molecule $\rightarrow$ formation of coacervate or microsphere



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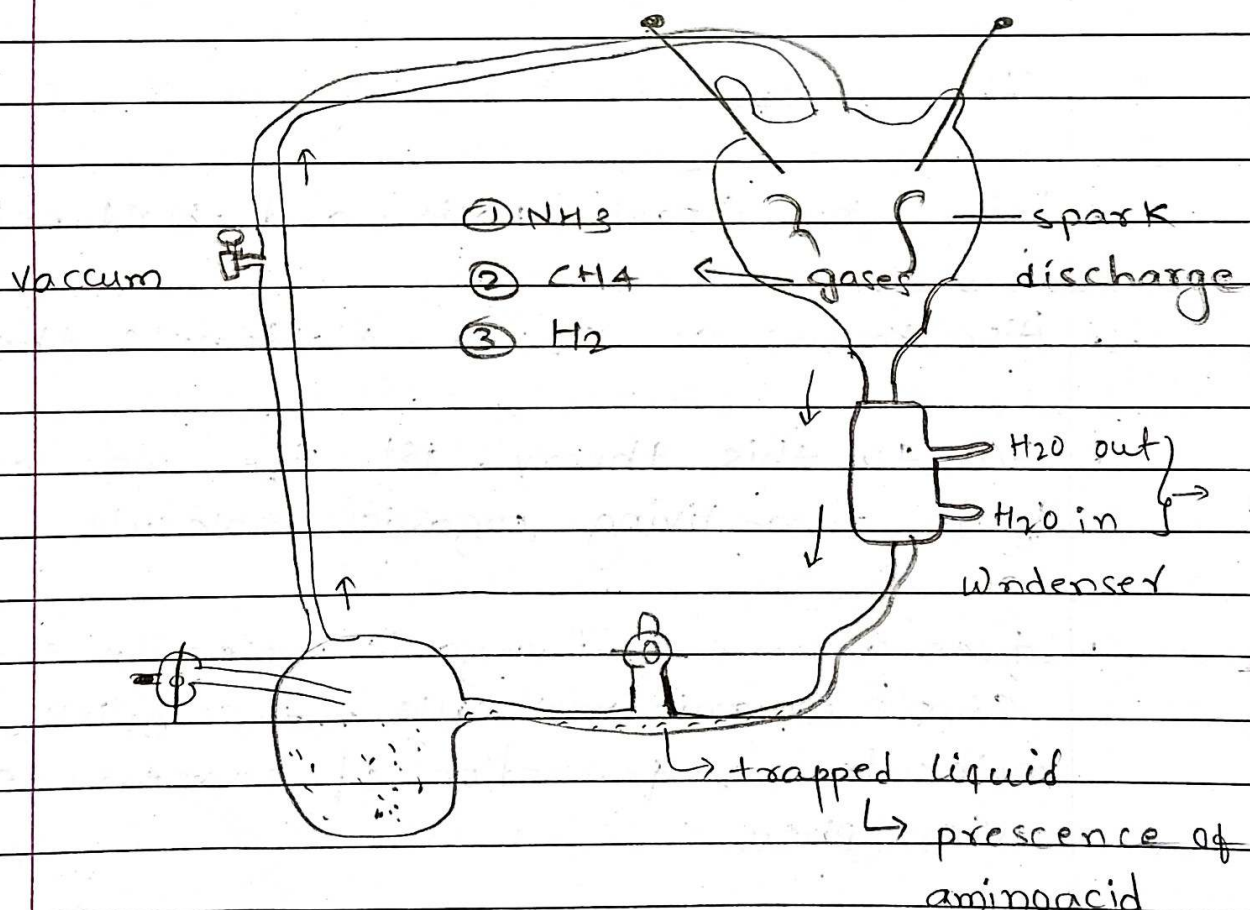
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note:- Microsphere & coacervates are also known as protobionts.

- Condition of primitive Earth -
High temp., volcanic storm, Reducing atmosphere,
atmosphere containing CH_4 , NH_3 , H_2 etc

- Chemical evolution was proposed by Haldane & Oparin but was experimentally proven by Miller & Urey (1953)

- Miller & Urey replicated the environment of primitive Earth in lab and proved theory of chemical evolution.



Experimental setup of Miller's experiment



* Miller's experiment

- Spark discharge experiment
- In the chamber, 3 gases were taken (CH_4 , NH_3 , H_2) 2:1:2
- Electrodes (tungsten) produce 75000 voltage
- Temperature = 800°C
- After 15 days, he observed formation of amino acid (glycine, Alanine, Aspartic acid)
- Similar experiments were conducted by different scientists. And they also observed formation of sugar, nitrogen base, fat etc.

Origin of universe $\div$ 20 ByA OR 13.8 ByA

Origin of Earth $\div$ 4.5 ByA

Origin of life $\div$ 4 ByA

Origin of non-cellular life (RNA, protein) $\div$ 3 ByA

Origin of cellular life $\div$ 2 ByA

* Sequence of evolution

Chemoheterotroph



Chemoautotrophs



Anaerobic photoautotroph



Aerobic photoautotroph



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Note:- Initially autotroph use H_2S . later autotroph use H_2O .

* Biological evolution

↳ induce by chemical evolution

- It explain the diversity present on earth.

(1) Lamarckism

- Lamarck was a french naturalist. He publish his book philosophie zoologique in 1809

- Key concept of lamarckism:-

(i) presence of internal vital force in all organism

↳ With this force all organism have the capability to make changes in organ or body

(ii) Effect of environment and new need

↳ Change in environment cause new need which further make changes in organs.

(iii) Use and disuse of organ

↳ more use of organ → more development

↳ no use of organ → start degenerating.

(iv) Inheritance of acquired characters

→ Acquired characters are those which are gained in lifetime.

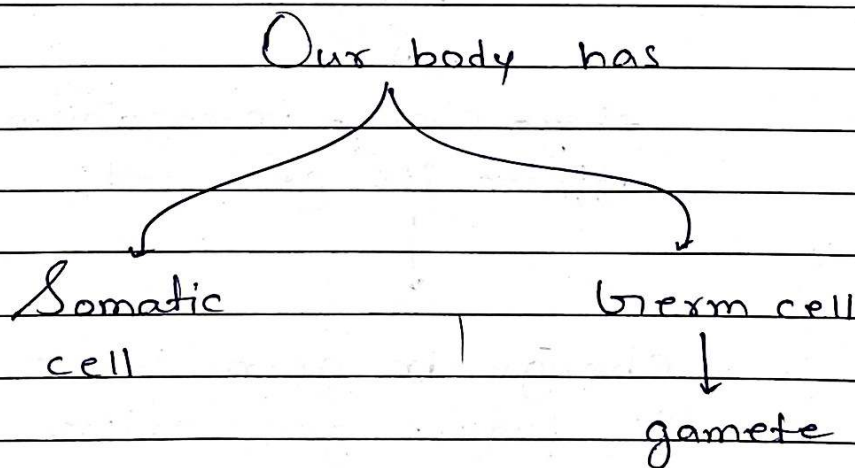


- A/c to Lamarckism, acquired characters are inherited in further generation.
- e.g of Lamarckism → long neck and limbs of giraffe.
→ limbless snake

Note: Presence of vestigial organ support this theory

- ✓ This theory is also known as 'Theory of use & disuse of organ' or Theory of inheritance of acquired character.

(2) Theory of continuity of germplasm



- This theory was given by August Weismann
- A/c to this theory, only those changes are inherited in future generations which are occurred in germ cell



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- Experiment done by Weismann
↳ cut tail of rat for 22 generation, still never tailless rat was born.
- Conclusion of experiment: Cutting of tail is not affecting germ cell, hence this character is not inherited.

(3) Neo Lamarckism

new ↳ theory of Lamarck

→ Many scientists redefined Lamarckism and give Neo-Lamarckism.

→ A/c to this theory:

Change in environment
↓

change in organism that
affects its germ cell
↓

Change in germ cell is inherited
in future generations.



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(4) Darwinism

Charles Darwin (born in 1809)

↳ HMS Beagle ship

Went for sea voyage for 5 years



Visited many islands, countries, but Galapagos island was the study centre.

- Galapagos island ÷ Collection of 22 islands
÷ in Pacific ocean
÷ located at western coast of South America

Alfred Wallace



Went on voyage and visit Malay Archipelago

↳

↳ located in Indian ocean

↳ Now, there is Malaysia and Indonesia

- Both scientists jointly proposed Theory of Natural Selection



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Both scientists were influenced by Essay on population written by Thomas Malthus.

- Both scientists concluded similar observations from studies during their voyage.
- Key concept of Theory of Natural Selection

(a) Overproduction

→ Organisms reproduce at maximal reproduction, at geometric ratio.

→ Differential reproduction takes place

→ Different organisms give birth to different numbers of offspring.

(b) Struggle for existence

→ Population of organisms increased. But resources are limited, as a result, there is struggle for existence.

3 types of struggle :-

(i) Intraspecific struggle

→ Members of same species compete for basic necessity.



(ii) Interspecific struggle

→ Members of different species struggle for basic necessity.

(iii) Environmental struggle

→ Struggle against extreme environmental condition like heat, cold, flood etc.

(c) Variation and heredity

→ No two individuals are same (except $\pm$ Monozygotic twins)

→ Variations exist in population

→ variation $\begin{cases} \rightarrow \text{useful} \rightarrow \text{Selected by nature} \\ \rightarrow \text{NOT useful} \end{cases}$

(d) Survival of the fittest

→ Individuals with great fittest fitness will survive and get selected by nature

→ Darwin talks about Reproductive fitness
(leave more progeny)

→ Survival of fittest idea given by Herbert Spencer

(e) Origin of New species

→ With generations, variation will get accumulated, and after many years new species is originated.



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Note:- A/c to Darwin, Variations are ÷ small, continuous and have directions

2 Key concept of Darwin

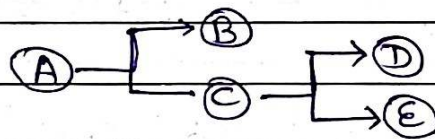
Nature selection

→ Gives idea about mechanism of evolution

Branching descent

→ Gives idea about pattern of evolution

→ Explain common ancestor of organism



↗ Change in DNA sequence

(5) Mutation theory

→ Given by Hugo de Vries

→ He worked on Evening primrose (Oenothera lamarckiana)

→ A/c to this theory, Evolution has take place due to Mutation

→ A/c to Vries, Mutation are ÷ large change, discontinuous and random or directionless

→ This theory is also known as 'Saltation theory' (large change in one step)



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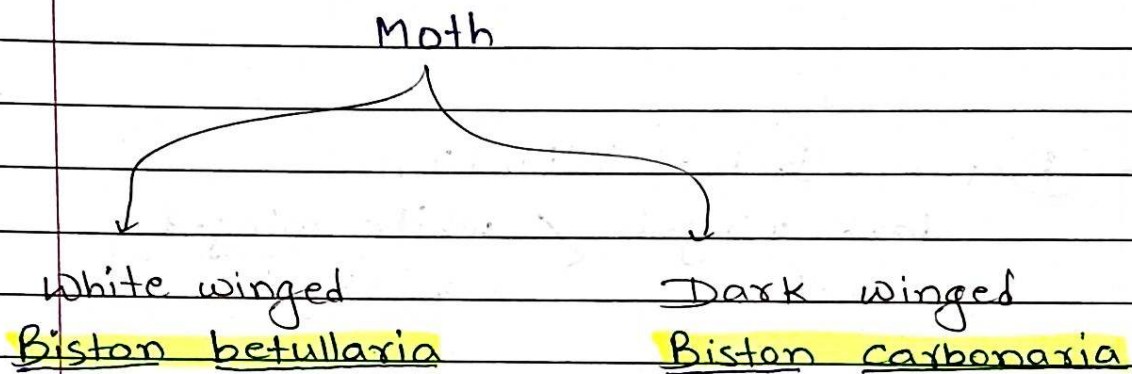
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- Example of natural selection

(i) Industrial Melanism

→ In England

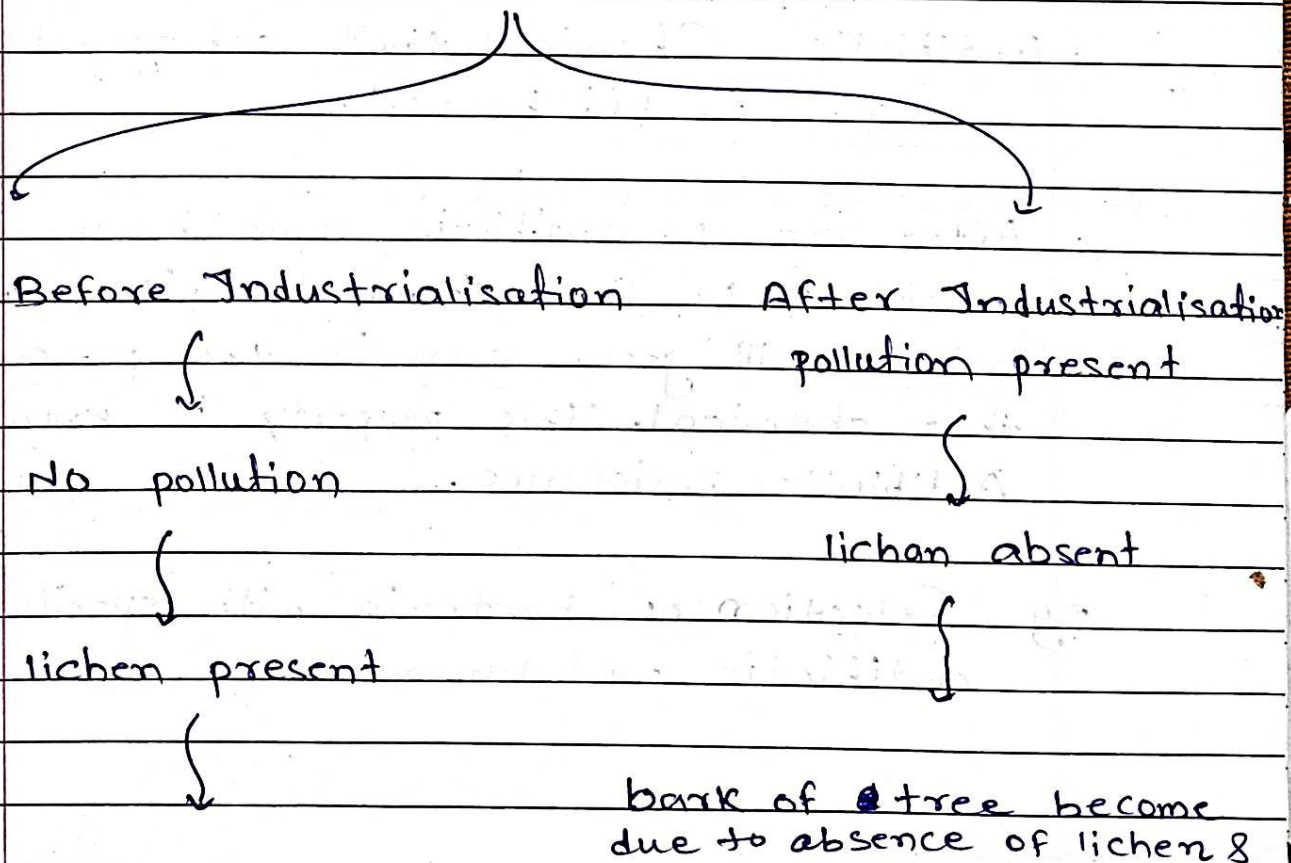
→ Observed on population of peppered Moth



→ Lichen is a pop 'pollution indicator'

[pollution present — lichen absent
pollution absent — lichen present]

Industrial revolution





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give white appearance
to bark of tree

presence of soot,
smoke etc

→ White winged moth
blended with background

→ Dark winged moth
blended with back-
ground

• Conclusion :-

→ Before Industrialisation

dark winged moth < white winged moth

→ After Industrialisation

Dark winged moth > white winged moth

(ii) Antibiotic Resistance.

• Antibiotic :- Chemical that act against bacteria
or kill bacteria

• After use of antibiotic, some bacteria become
resistant to that chemical, which means
bacteria will grow even in the presence of
that chemical. This property is known as
Antibiotic Resistance.

eg. Selection of bacteria with specific -
antibiotic resistance



(6) Neo-Darwinism

- Also known as Modern synthetic theory of evolution
- Darwinism + Mendelian genetics
- Explain arrival of fittest, source of variation

Note: unit of evolution = population

unit of natural selection = individual

Source of variation

- (a) Migration (b) Genetic Recombination
- (c) Mutation (d) Genetic Drift (e) Natural selection

* Migration or Gene flow

• Movement of individuals from one place to another

• Migration result in Gene flow

• Migration $\left\{ \begin{array}{l} \rightarrow \text{Emigration (exit or out)} \\ \rightarrow \text{Immigration (in or entry)} \end{array} \right.$

* Genetic Recombination

• During cell division, crossing over takes place

• Resulting Resulting in exchange of section of chromosome among chromosome

• Source of variation



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* Mutation

- Change in base pair in a polynucleotide chain (DNA)
- Source of variation
- Random and directionless in nature

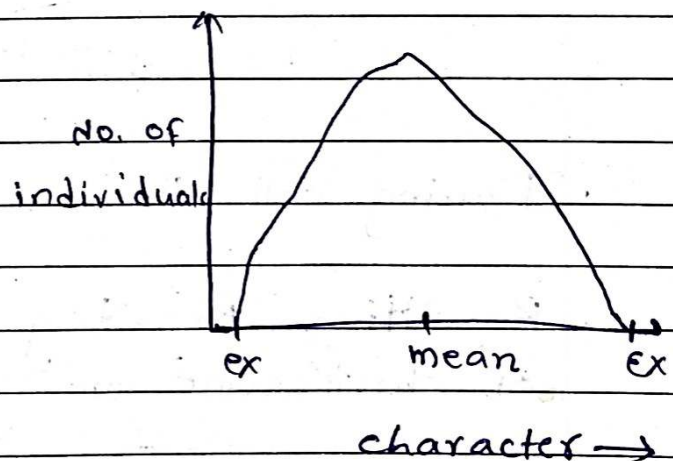
* Natural selection

- Nature selects individual with +ve variation and support fittest.

• Types of Natural selection

(a) Stabilising selection

- In this, individuals with mean/average/intermediate characters are selected.
- Individuals with extreme characters are eliminated
- It indicates unchanged/constant environment
- e.g. height of individual





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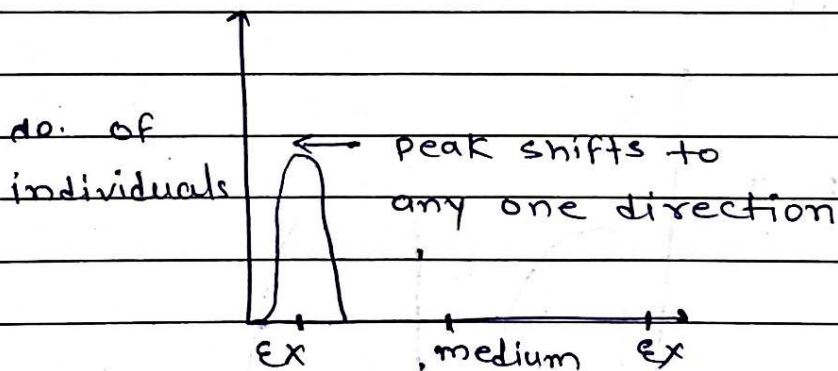
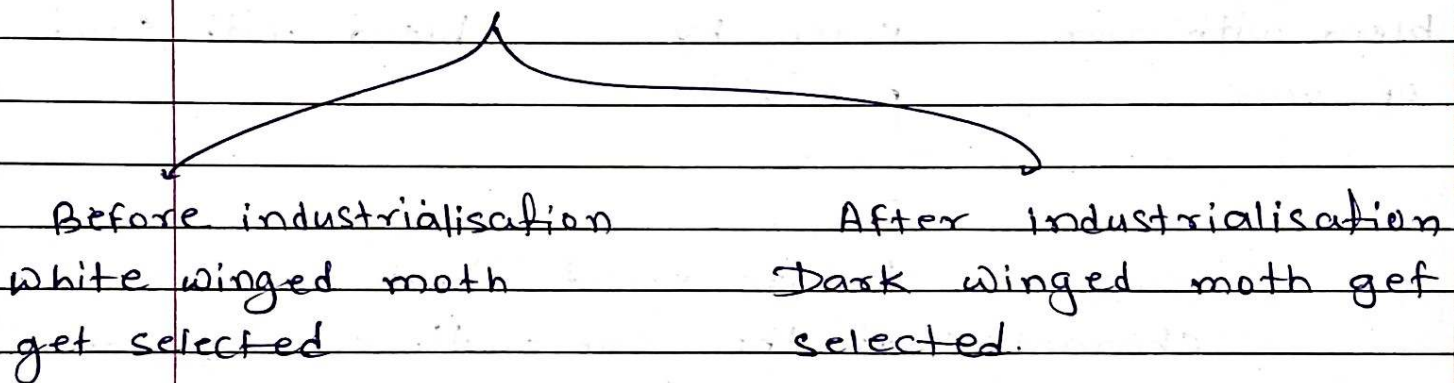
→ With time peak gets narrower and longer

(b) Directional/progressive selection

→ In this the peak shifts to any one extreme character

→ Nature selects any one peripheral character at a time.

e.g. Industrial melanism



(c) Disruptive selection

→ In this, nature selects both extreme character at the same time

→ Mean character is not favoured by nature



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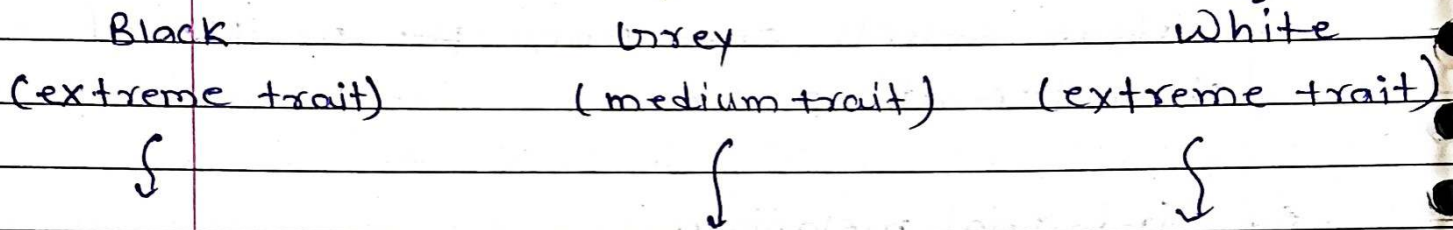
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→ 2 peaks are found in this type of selection

→ e.g.

Mollusca/salt snail

have 3 color of cell

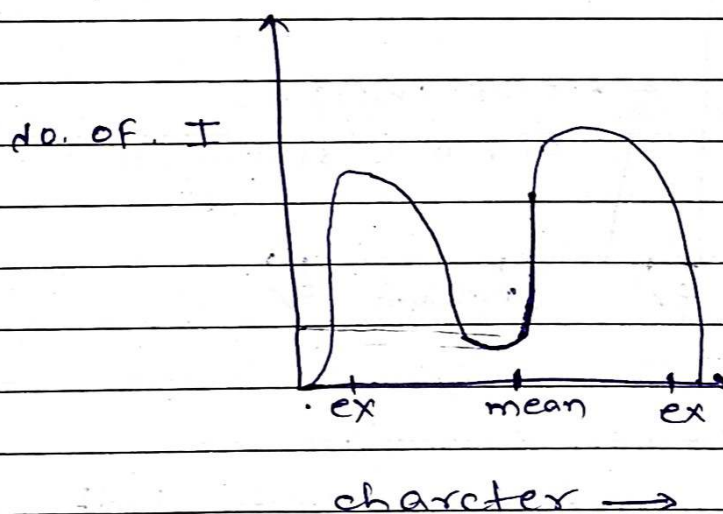


blend with color
of rock

eaten by
predator

blend with sand

Conclusion: Nature selects both extreme character at the same time, not medium character.





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* Genetic Drift

- Change in allelic frequency due to by chance factor
- Random in nature
- Its impact is seen in small population
- Also known as Sewall Wright effect or Scattering of Variability

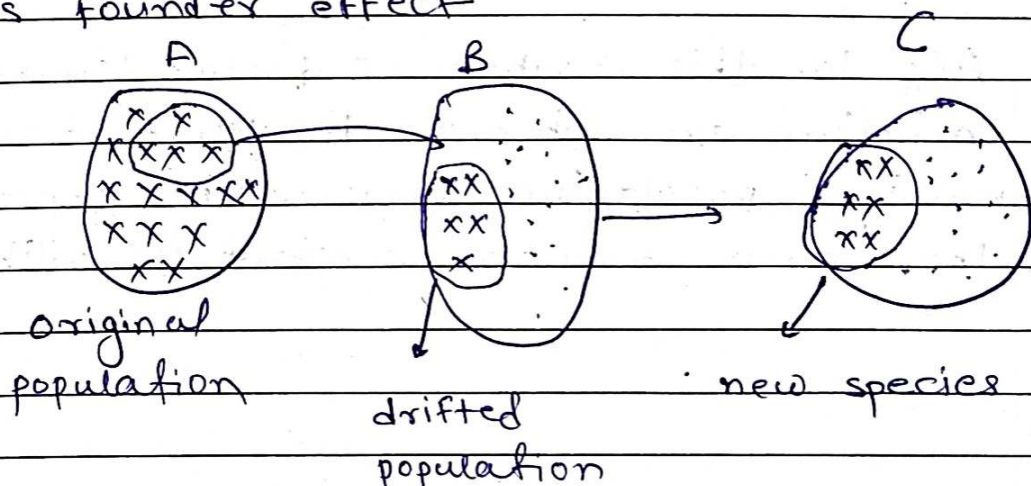
Genetic Drift
result in

Founder
effect

Bottleneck effect

- Founder effect
When drifted population give rise to new species in a new geographical isolated location

→ It means Drifted population become the founder of new species. This effect is known as founder effect

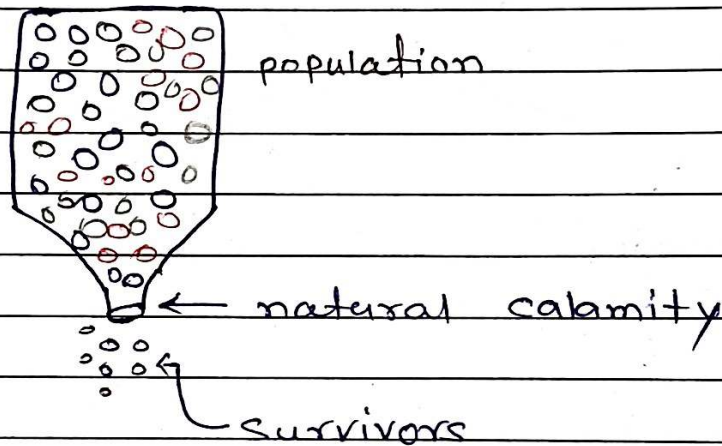




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- Bottleneck effect
- Random change in allelic frequency in a population due to natural calamities
- This cause loss of genes and loss of traits
- Survivors mate & regain population size and may form new species in future



* Hardy Weinberg Equilibrium

- Given by Hardy & Weinberg
- A/c to this, when 5 factor (source of variation) are absent in large, random mating population then the gene pool of the area remain constant (Equilibrium)



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- 5 factors affecting Hardy - Weinberg equilibrium are ÷ Mutation, Migration, Genetic Recombination, Natural selection & Genetic Drift

• Gene pool → Sum of all gene & its alleles.

- Hardy - Weinberg Equation

$$p + q = 1$$

p = frequency of dominant allele

q = " " " recessive allele

$$p^2 + q^2 + 2pq = 1$$

p^2 = frequency of homozygous dominant condition

q^2 = frequency of homozygous recessive condition

$2pq$ = frequency of heterozygous condition

- Q. Frequency of $A = 0.7$
frequency of $a = 1 - 0.7 = 0.3$

- Q. Total population = 1000

$$AA = 360$$

$$Aa = 480$$

$$aa = 160$$

Find frequency of $A = \frac{360 + \frac{480}{2}}{1000} = \frac{600}{1000} = 0.6$



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Q Frequency of $A = 0.4$

Find AA , Aa , aa

$$\rightarrow AA = (0.4)^2 \rightarrow 0.16$$

$$Aa = 2 \times 0.4 \times 0.6 = 0.48$$

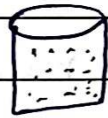
$$aa = (0.6)^2 = 0.36$$

add = 1

* Lederberg's experiment

• Done by Lederberg scientist

• Experiment +



Medium A

bacteria growing in medium A
over several generation



Medium B

(contain penicillin)

↳ Antibiotic



Result ÷ Only few bacteria survived in Medium B. Only those bacteria survived which were having pre-existing advantageous - mutation (Resistance against penicillin)

* Isolation

- When members of same species become separated from original population due to any reason

For e.g. formation of mountain (physical barrier that members of population can't cross)

* Reproductive isolation

- Isolation due to reproductive reason (some members of same species is not able to reproduce with original population)

Reproductive isolation

pre-zygotic

post-zygotic

→ No fertilisation

→ Formation of sterile organism

→ No formation of zygote



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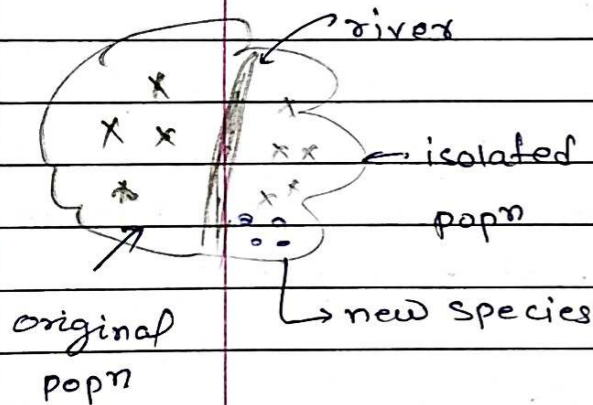
* Speciation

- formation of new species is known as speciation.

Speciation

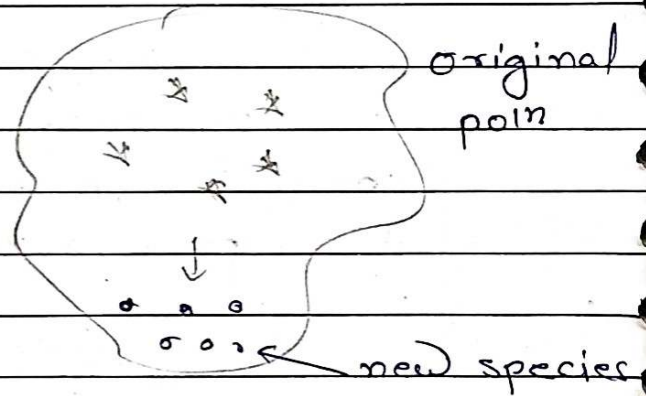
Allopatric

→ formation of new species due to geographical isolation



Sympatric

→ formation of new species in the same population at the same geographical location.





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* Evidences for evolution

① Fossils

→ Study of fossils is known as palaeontology

Palaeontology

Palaeobotany

→ Study of plant fossils

Palaeozoology

→ Study of animal fossils

→ Fossils are remains of hard parts of life forms found in rock

→ Generally found in Sedimentary rock

→ e.g of fossils = imprints, excreta, bones etc.

• Age of fossils

↳ Determined by +

① Carbon Dating method

→ Isotopes of carbon is analyse

→ ratio of different isotopes of carbon is used to know the age of fossils

ex. of living fossils = *Amphioxus*, *Varanus*, *Lamprey*



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(b) ESR (Electron spin resonance)

→ recent technique

→ give accurate result

(c) Relative method

→ fossils found near the surface of earth is recent while fossils found in deep layers of earth is comparatively older

eg.

(A)

(B)

(B) is recent in comparison to A

(2) Morphological and Anatomical evidence

- Homologous Organ



same origin

Same ancestor but different function

Same structure

→ Homologous organs indicate common ancestor

→ Due to different environment, different needs



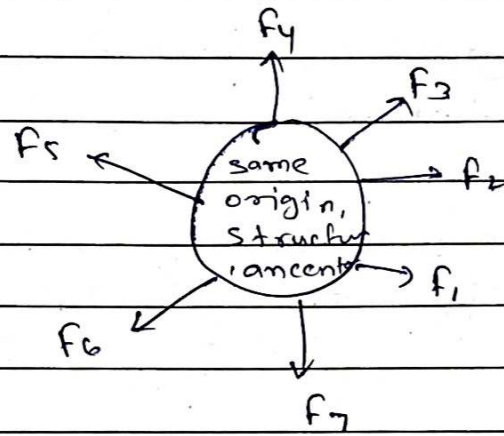
Some structure perform different function



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→ Homologous organ is also known as -
Divergent evolution



$f_1 - f_2$ are different function

e.g. (a) ~~Fore~~ forelimbs of cheetah, whale, bat, human
(same structures - humerus, radius, ulna etc)
(different function)

(b) Thorn of bougainvillea and ^{Support} tendril of cucur-
bita
(both arise from axillary bud, different function)

(c) Hearts and brains of vertebrates

(d) Mouth parts of cockroach, honeybee, mosquito
(same structure maxillae, mandible, function different)



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• Analogue Organ

→ Different ancestor

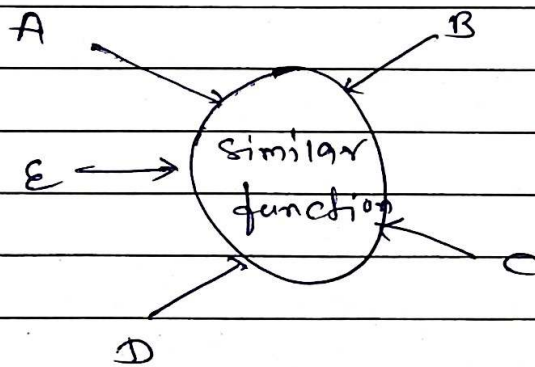
Different origin but Similar function

Different structure

→ This happens due to some environment, some needs of different organ living in similar conditions.

→ Analogue organ indicates different ancestry.

→ Analogue organ indicates Convergent evolution



e.g. a) potato and sweet potato
(stem modification) (root modification)

→ both store food

b) Wings of butterfly and birds

c) Eye of octopus and human



(1) flippers of penguin and dolphin

(3) Biochemical Evidences

→ On the basis of similarities in genes and protein found in different animals indicates common ancestry

e.g. Trypsin enzyme

(4) Vestigial organ

→ Vestigial organs are those organs which are present in reduced form and non-functional form now. But they are functional in ancestor and animals having common ancestor.

e.g. of vestigial organs in human

- nipples in male
- body hair
- third molar (wisdom tooth)
- muscle of ear pinna
- appendix
- Tail bone (coccyx)

note: Atavism

↳ Reoccurrence of ancestral trait
e.g. presence of tail in new born



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⑤ Biogenetic law/embryological evidences

→ Given by

→ A/c to him embryos of all higher vertebrates have certain characters that is absent in adult form. e.g. gill slit is present in human embryo that is absent in adult human

* Adaptive radiation

Adaptation

→ radiating in different dirⁿ

→ When members from original population in a geographical location move to different geographical location. Then due to different location some changes occur in them. Due to which many varieties (species) are formed. This is known as Adaptive radiation

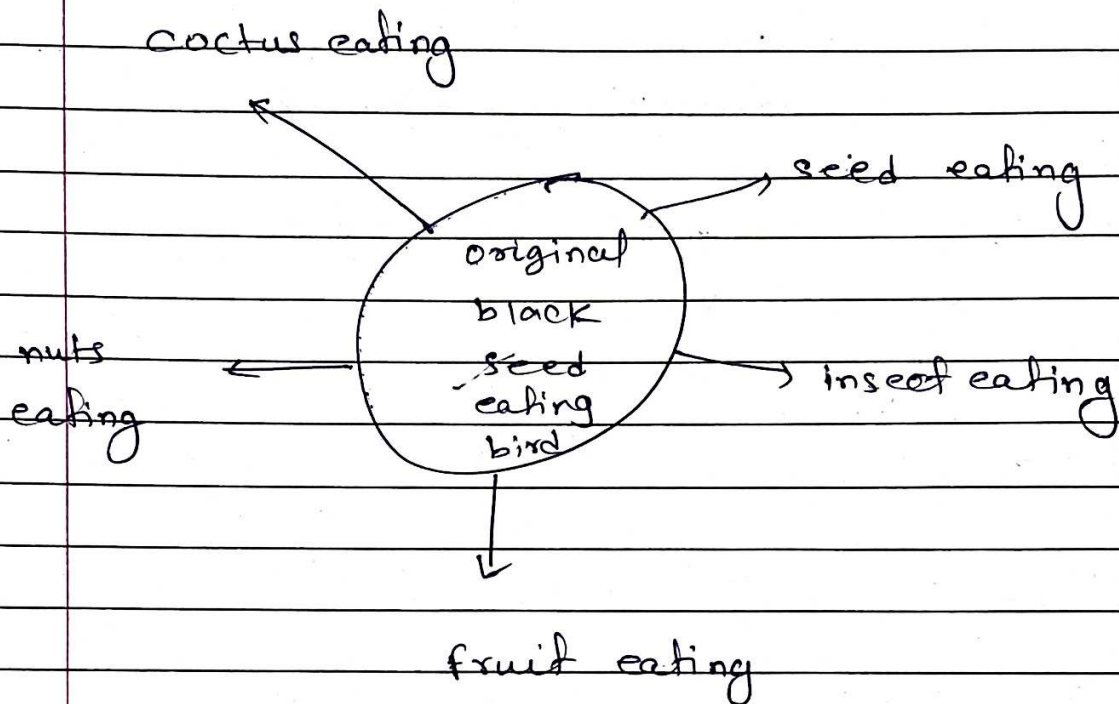
→ It is Divergent evolution



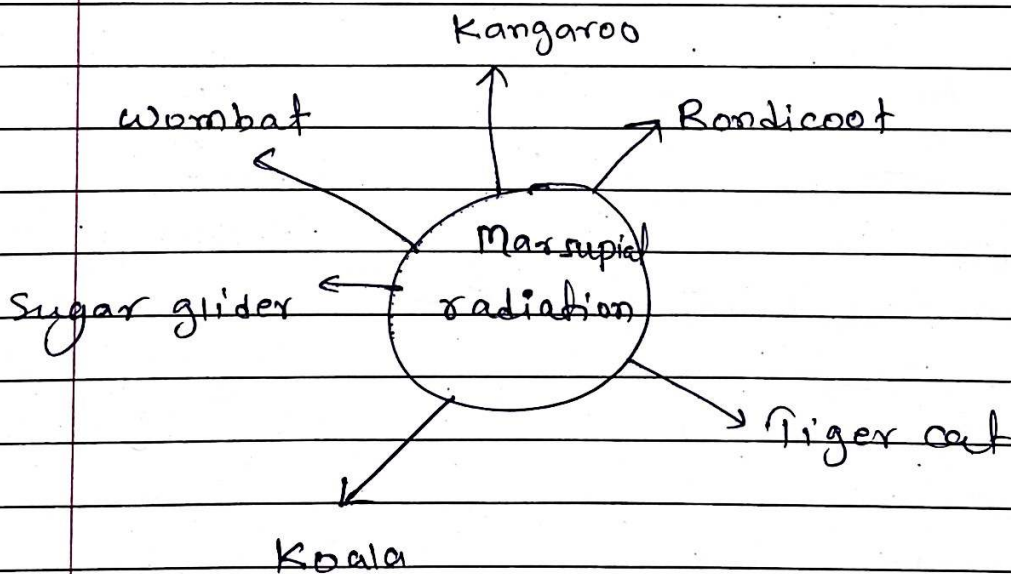
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e.g. (i) Darwin's finches



(ii) Australian Marsupials

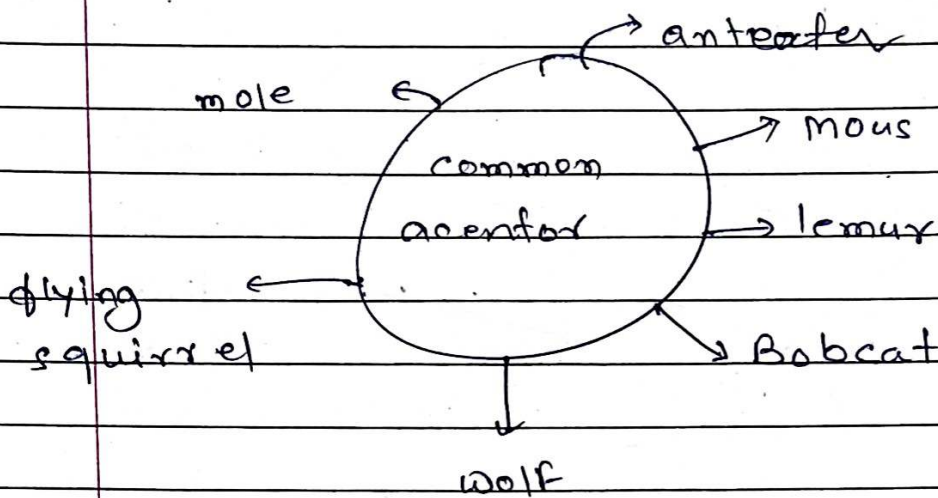


(iii) placental mammal



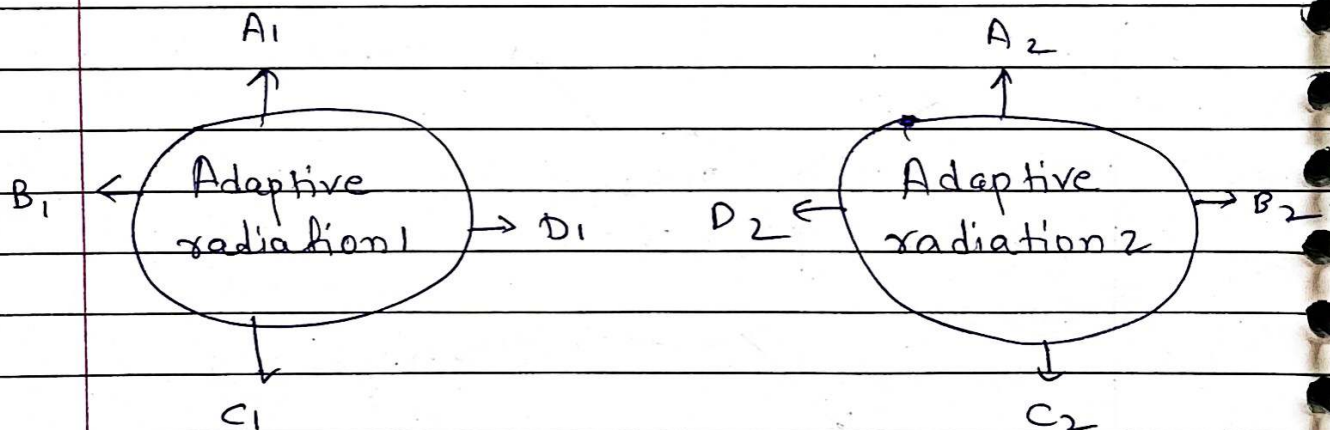
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* Convergent evolution

→ When more than 1 adaptive radiation take place at the same geographical location, then the members of both radiation show similarity among themselves. (Due to same environment, same need)



In above example, 2 adaptive radiations are taking place at same location

$$\begin{aligned} A_1 &\approx A_2 & D_1 &\approx D_2 \\ B_1 &\approx B_2 \\ C_1 &\approx C_2 \end{aligned} \quad \approx \leftarrow \text{Similar}$$



placental mammal

Marsupial mammal

mole → Marsupial mole

Anteater → Numbat

Mouse → Marsupial mouse

Lemur → Spotted cuscus

Flying squirrel → flying phalanger

Bobcat → Tasmanian tiger cat

Wolf → Tasmanian wolf

* Evidences from Connecting link

- Organism that connect two groups of organism
- Have characters of both group

- Virus ÷ b/w living and non-living
- * Euglena ÷ b/w plants and animal
- protospongia ÷ b/w protozoa and porifera
- * Neopilina ÷ b/w Annelida and Mollusca
- * peripatus ÷ b/w Annelida and Arthropoda
- Balanoglossus ÷ b/w Non-chordata & chordata
- Chimera ÷ b/w Cartilaginous and bony fishes
- Protopterus (lung fish) ÷ b/w pisces and Amphibia
- Seymouria ÷ b/w Amphibia and Reptilia
- * Archaeopteryx ÷ b/w Reptilia and Aves
- platypus and Echidna ÷ b/w Reptilia and Mammalia



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- Origin of first cellular life form — 2 ByA
- Origin of invertebrate — 500myA
- Origin of jawless fish — 350myA
- Sea weeds and plant — 320myA

→ The first organism that invaded land were plants

→ Lobbed fins fish (fish with stout and strong fins) (coelacanth fish) 350myA move on land and returned back in water. Thought to be extinct. But in 1938 in south Africa this live (living fossil) fish was caught.

→ Lobefins gave rise to first amphibia (lived on both land and water)

→ Amphibia were second organism but first animal that migrated from water to terrestrial habitat.

→ Amphibia gave rise to reptiles. They lay thick shelled eggs (which protect their egg from heat) (terrestrial adaptation) (first terrestrial vertebrate)

→ Some reptiles returned back to water and form fish like reptiles (Ichthyosaurs) (200myA)

↳ Not found now



* Archeopteryx

↳ connect reptiles and aves

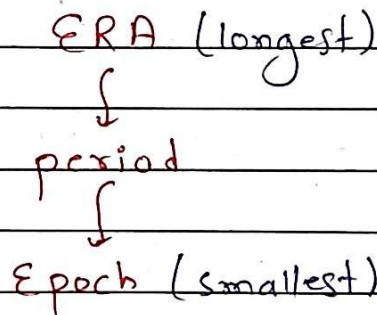
• Reptiles

↳ long tail, teeth, weak sternum, heavy bone, free caudal vertebrae

• Aves

↳ feathers present, forelimbs modified into wings, beak present

* Timeline of evolution



• Eras

- ① Azoic (oldest)
- ② Archaeozoic
- ③ Proterozoic
- ④ Palaeozoic
- ⑤ Mesozoic
- ⑥ Cenozoic (recent)



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- Palaeozoic era
↳ period : Cambrian, Ordovician, Silurian
Devonian (age of fishes), Carboniferous
(age of amphibians), Permian
- Mesozoic era (age of reptiles)
↳ period : Triassic, Jurassic, Cretaceous
- Cenozoic (age of mammals)
↳ period : Tertiary, Quaternary

* Origin and Evolution of man

① Dryopithecus

- Arose about 15mya
- More like ape
- Hairy
- Walked like chimpanzee and gorilla
- Common ancestor of man and ape

② Ramapithecus

- Arose about 15mya
- more man like
- Oldest human ancestor
- Cranial capacity 600cc



③ Australopithecus

- Connecting link b/w ape and man
- Man like primates
- Arose about 2mya
- Hunted with stone weapons (entertainment)
- Vegetarian

④ Homo habilis

- First human like (hominid)
- 650-800cc
- First tool maker
- Vegetarian
- Fossils found in African caves.

⑤ Homo Erectus

- Arose about 1.5 mya
- 900cc
- Used fire and probably eat meat
- Fossils were discovered in Java in 1891 (Java-man), in China (Peking man), in Germany (Heidelberg man)

⑥ Neanderthal man

- Fossils first obtained from Neander valley in Germany
- Arose about 100000-40000 years back
- 1400cc
- Used hides to protect their domestic animals & themselves.
- Bury their death dead



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⑦ Cromagnon

- Earliest form of Homo sapiens
- 1650 cc
- Cave paintings and arts e.g. Bhimbetkar rock shelter in Raisen MP

⑧ Homo sapiens

- living modern
- Arose in Africa and moved across continents
- Agriculture and human settlements.

Dryopithecus → Ramapithecus → Australopithecus
→ Homo habilis → Homo erectus
Homo neanderthal → Homo sapiens

Dinosaurs (suddenly disappeared around 65 MYA)

Reason: climate change.

- most of them evolved into birds
- ~~Some~~ Small reptiles exist now

→ Birds originated from reptiles (Archaeopteryx)



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- Reptiles (Therapsid) gave rise to mammals. First mammals were like shrews
- Mammals were viviparous and more intelligent, which ensures their continuity on land.